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NATURAL HISTORY
SURVEY

SITE-SPECIFIC SUBSTRATE MAPPING OF JULIAN'S REEF

Federal Aid Project F-108-R

Final Report

Center for Aquatic Ecology

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Abstract

Julian's Reef was surveyed by side-scan sonar and remotely operated video during August, 1990. 1086 egg traps and 932 egg nets were then deployed in ten gangs over areas of the reef judged, on the basis of the initial side-scan sonar and video results, to offer the best lake trout spawning habitat. Inspection of egg-collection devices immediately after deployment showed that 98% of the traps and 92% of the nets were fishing (i.e., capable of catching eggs). ROV inspection of some gangs in November showed that 90% of the traps and 46% of the nets were still fishing. 520 egg traps and 621 egg nets were recovered intact during December. No lake trout eggs were found. A substrate map of the southern half of Julian's reef was prepared based on the side-scan sonar and video data. The substrate type offering the best shelter for lake trout eggs (described as bedrock and rubble) constituted 8.55% of the area surveyed. Within that substrate type less than 15% of the substrate provided physical structure described by others as suitable habitat for lake trout eggs and fry. Despite the effort to place egg-collection devices over good substrate, most missed those small areas of superior substrate. With the large numbers of egg-collection devices and the substrate map available from this study, future egg-collection attempts targeting the best spawning substrate on Julian's Reef can be made at low cost.

Introduction

Since 1981 over one million yearling lake trout have been stocked directly over Julian's Reef (Fig 1). Although survival of stocked fish has been good and aggregations of ripe adults are found over the reef during spawning seasons (Rich Hess, Illinois Department of Conservation, personal communication), no direct evidence for natural reproduction by those stocked fish exists. Efforts to recover spawned eggs from Julian's Reef prior to this study were unsuccessful (Horns et al. 1989).

This project addressed the following objectives: 1) To obtain side-scan sonar images for all of Julian's Reef. 2) To intensively explore by remotely-operated vehicle (ROV) and videotape the areas that, after study of the side-scan sonar images, appear most promising for lake trout spawning. 3) To deploy with ROV assistance 2,000 egg-collection devices on the best-looking spawning areas, as identified from study of the videotapes. 4) To recover the egg-collection devices for estimation of egg deposition rates.

Julian's Reef is a small, rocky outcrop reaching a minimum depth of 24 m about 14 km east of Fort Sheridan, Illinois in southwestern Lake Michigan (Fig. 1). The reef lies near the 38 m depth contour on the gently sloping lakebed. Holm et al (1987) described the reef as composed of Silurian bedrock overlain in places with broken rock and sand.

Methods

Substrate mapping (Study 101)

Data for substrate mapping were collected during August 24-28, 1990. We surveyed and mapped the lakebed with an EG&G (mention of brand names does not imply endorsement) side-scan sonar system, which included a Model 260 microprocessor, Model 360 digital tape, and Model 272 100 kHz towfish with time-varied gain. Survey and mapping methods were virtually identical to those used earlier in studies of lake trout spawning grounds throughout the Great Lakes (Edsall et al. 1989, Edsall 1990a,b). We deployed the towfish from a cable and davit over the side of the survey vessel and adjusted the length of the cable so that the towfish ran 10 to 17 m beneath the surface when the vessel cruised at 7.4 km/h (4 knots). The towfish directed an acoustic signal to the lakebed, received and amplified the echo from the lakebed, and transmitted it to the microprocessor. The microprocessor converted the signal into a continuous strip chart record showing, in plan view, the physical features of the surface of a 200-m wide strip of lakebed beneath the towfish. We pulled the towfish along a series of parallel transects that covered the survey area and followed Loran C isograms. Transect spacing was about 120 m to ensure overlapping representation of the lakebed on strip chart records for adjacent transects.

To facilitate interpretation of the side-scan records we examined the lakebed in the survey with a Benthos, Inc. Mini-Rover MK II remotely operated submersible equipped with a color video camera. Locations of video transects prior to deployment of egg nets and traps are indicated by unlabelled solid line segments in Fig 2c. Following deployment of the egg-collection devices all devices were videotaped, providing 10 additional video transects (numbered solid line segments in Fig 2c). The MK II was deployed on a tether by an operator who guided its movements with joystick controls, while monitoring the video camera images transmitted to a shipboard closed circuit video monitor. An alph-numeric display of the depth at which the MK II was operating and the compass heading it was following was superimposed on the images of the lakebed and the entire screen display was videotaped to provide a permanent record of the lakebed.

The skids on the underside of the MK II extended into the field of view of the video camera and the distance between the skids (18 cm) was used as a scale to estimate the size of rocks and other lakebed objects recorded on the videotapes. The substrate interstitial depth (the vertical distance that lake trout eggs and fry could gravitate into loose rock substrates) was estimated from the size composition and amount of piling of the loose rock, and the degree to which sand or other fine sediments appeared to have infiltrated the loose rock substrate.

In the laboratory we assembled the strip charts to form a 1:1000 scale "mosaic" map of the area that we surveyed. Substrate components were classified according to a modified Wentworth scale as sand (<2 mm), gravel (2-64 mm), rubble (65-256 mm), cobble (257-999 mm), or boulders (>999 mm). Where these components occurred in mixtures, we described the mixture on the basis of the two components that covered the largest and second largest amounts of lakebed.

We also constructed a bathymetric overlay for each mosaic map using the graphic information displayed on the margin or "profile" section of each strip chart composing the mosaic (Edsall et al. 1989). We digitized the mosaic maps and bathymetric overlays, entered them into a geographic information system, and produced a computer-drawn map showing the distribution of major substrates and the bathymetry of the surveyed area.

Illustrations of the substrates (Figs 3-10) were obtained in the laboratory by photographing videotape images of the lakebed that were displayed on a television moitor.

Deployment and recovery of egg-collection devices (Study 102)

Two types of egg-collection devices were used, egg nets and egg traps. The egg nets were described by Horns et al. (1989); the egg traps were described by Marsden and Krueger (1990). The nets and traps were deployed attached to ropes in 9 gangs of 200 and one of 218. The devices were attached five feet apart. In nine of the ten gangs devices were attached alternately, and 100 of each were attached. One gang (number 10 in Table 1) had 186 traps and 32 nets. The nets were attached to the ropes and deployed as described by Horns et al. (1989). The traps were tied to the ropes with three-foot lengths of seaming twine. The traps were individually numbered. Each gang of devices was anchored at each end with a one-gallon concrete anchor and marked at each end with a surface buoy.

The devices were deployed over Julian's Reef during the August 24-28 survey of the reef. We attempted to place the devices on areas of the reef offering the most potential shelter for lake trout eggs (Fig. 2). All traps and nets were videotaped following deployment. Those tapes were the basis for classifying each trap and net as fishing or not fishing. A device was classified as fishing if it appeared that a lake trout egg released immediately over it would be captured. Traps on edge and upside-down nets were classified as not fishing. On November 13, 1990, all or part of four gangs were examined by remotely operated video camera. Traps and nets viewed on this date were classified as fishing or not fishing. Instances were noted where devices had been broken off (designated as missing in Table 1). On December all gangs were recovered except two entire gangs for which both bouys were missing and two partial gangs that were lost when the connecting rope broke (Table 1). For each gang the originally deployed devices were classified as recovered intact, damaged (i.e., incapable of retaining eggs), or missing (broken off). All intact devices were examined for the presence of lake trout eggs.

Results

Substrate mapping (Study 101)

We mapped 155 ha of lakebed on the southeast side of Julian's Reef at water depths of 24 to 46 m (Fig. 2). From the side-scan sonar record and from the videotapes made on 17 transects covering a total of about 6.9 km of lakebed, we identified eight major substrate types ranging from bedrock to silt (Fig 2).

"Bedrock" (Fig. 3) dominated the reef crest (Fig. 2). The bedrock was flat or inclined pavement that was jointed and extensively pitted in places. In some areas the pits were circular, about 2 cm in diameter, and 2 cm deep, whereas in others the pits coalesced producing large cavities of irregular shape. A thin veneer of fine sand was present on much of the bedrock and was most easily seen where it accumulated in the pits. Individual cobble- and boulder-sized rocks occurred at widely spaced intervals across the reef crest. Interstitial depth was essentially zero on this substrate.

"Bedrock ridges" (Figs. 4-6) was the dominant substrate in three areas (Fig. 2). The bedrock ridges substrate closely resembled the bedrock substrate at the reef crest except that the pavements were stepped. These steps, which were produced by the removal of several layers of bedrock along one side of a joint in the pavement, ranged from a few centimeters to more that meter in height. Scattered loose rock was somewhat more common on the bedrock ridges substrate than on the bedrock substrate at the crest of the reef.

"Bedrock and rubble" substrate (Figs. 7-8) bordered the reef crest on the south and a second smaller patch occurred southeast of the crest (Fig. 2). In these two areas, the bedrock was more extensively fractured and rock rubble occurred in piles along pavement steps an in accretion areas that buckled upward in places creating piles of rubble. Although most of the loose rock was rubble-sized, cobbles and the occasional boulder were also present. The boulders were rounded and may have been brought into the area by glacial action. Interstitial depths exceeded 20 cm in some of the larger piles of rubble.

"Bedrock and sand" and "Bedrock and silt" (Fig. 9) substrates composed the eastern edge of the reef (Fig. 2). These two substrates had similar bedrock components and differed only in terms of the type of the fine material (sand or silt) that covered much of the bedrock. At depths less than about 36 m the bedrock resembled the bedrock and bedrock ridges substrates near the crest of the reef. At greater depths the bedrock was more deeply and extensively jointed and rounded, giving it a lumpy appearance. More loose scattered rock was present than on the bedrock pavements near the crest of the reef and a thin layer of sand or silt covered most of the rock surface.

"Sand and rubble" and "rubble and sand" (Figure 10) substrates bordered the reef on the south and and southeast. The two substrates were similar and differed from each other only in the relative amounts of lakebed that was covered by the sand and rubble components. The rock rubble in both of these substrates was heavily infiltrated with sand and the interstitial depth in both was zero.

"Sand and silt" substrates bordered the reef on the eastern side of the mapped area. Interstitial depth was zero there.

Project F-108-R Performance Report

Study 101. Substrate mapping by side-scan sonar and ROV-controlled videotape.

Job 1. Side-scan sonar.

Objective: Obtain side-scan sonar images of all of Julian's Reef and the surrounding lake bottom.

Progress: The desired side-scan sonar images were obtained and utilized in the preparation of the substrate map presented here (Fig 2).

Job 2. Videotape.

Objective: Obtain videotape images of those areas identified from the sonar tapes as providing the best hope of containing high-quality spawning habitat.

Progress: Extensive videotape images were obtained, as planned, and utilized in the deployment of egg-collection devices and in the preparation of the substrate map presented here (Fig 2).

Study 102. Deployment and recovery of egg-collection devices.

Job 1. Preparation.

Objective: Prepare and rig 2000 egg-collection devices.

Progress: 2018 egg-collection devices were prepared and rigged.

Job 2. Deployment.

Objectives: 1) Deploy 2000 egg-collection devices over areas of Julian's Reef that appear from examination of sonar and videotapes to offer the best lake trout spawning substrate. 2) Obtain videotape images of 200 to 400 egg-collection devices following deployment.

Progress: 1) 2018 were deployed in August, 1990. 2) All devices were videotaped immediately following placement. 597 devices were videotaped again in November, 1990.

Job 3. Recovery.

Objective: Recover the egg-collection devices following spawning.

Progress: 1472 egg-collection devices were recovered in December, 1990.

Deployment and recovery of egg-collection devices (Study 102)

98% of traps and 92% of nets were fishing immediately after deployment in August (Table 1). On November 13, 90% of the re-checked traps and 46% of re-checked nets were still fishing (Table 1). When the gangs were recovered on December 10, two entire gangs and portions of two others were lost. Of devices that had originally been attached to recovered portions of gangs, 64% of the traps and 94% of the nets were intact (Table 1). The total numbers of traps and nets that were fishing and recovered intact were estimated by multiplying the numbers recovered intact by the fractions fishing in November. In that way we estimate that we recovered 468 traps and 286 nets that might have caught eggs. No eggs were collected.

Discussion

Of the eight substrate types we identified in the mapped area, only the piles of rubble with interstitial depths of 20 cm or more that occurred in the bedrock and rubble substrate provided physical structure described by others (Wagner 1982, Nester and Poe 1984, Peck 1986, Marsden et al 1988, Marsden and Krueger 1990, Marsden and Krueger 1991) as suitable habitat for eggs and fry of shallow-water strains of lake trout that are currently being stocked in the Great Lakes. These rubble piles were patchily distributed and probably covered less than 15 percent of the lakebed in the bedrock and rubble areas shown in Fig. 2. Patch size ranged from about 10 to 100 m^2 and the largest patches were near where transects 3, 13, and 14 intersected with the 26 m depth contour.

Inspection of the egg-collection devices immediately after placement and again in November indicated that a large proportion were functioning properly. The traps fished better than nets, in the sense of falling and remaining in positions that would allow capture of eggs. Many devices were lost (entire gangs or parts of gangs lost), missing (individual devices broken off), or damaged (recovered, but incapable of retaining eggs) at the end of the study. The large loss rates (25% of traps and 29% of nets), the large proportion of missing or damaged traps (36% of traps not lost), and the large proportion of non-fishing nets (54%) can to some extent be attributed to the long duration of the study. We deployed the traps and nets in August in order to assure good weather for video inspection of the devices on the lake bottom. With deployment in late October and recovery in late November, the performance and survival of gear could be expected to far exceed what was observed here.

Marsden and Krueger (1991) found that on Stony Island Reef in Lake Ontario lake trout were highly selective of spawning sites and used only a small fraction of available reef area. Thus, although the videotapes show that some traps and nets were placed on promising substrate, our failure to collect lake trout eggs may still reflect an inability to place collection devices on the areas selected by the lake trout for spawning.

With large numbers of nets and traps now available for future use and with the substrate map presented here as a guide, future efforts to recover lake trout eggs from Julian's Reef can be conducted at low cost and with some hope of success.

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Tables

Table 1. Egg net and egg trap deployment, check, and recovery. Ten gangs of 200 or 218 devices were deployed on August 24-28. Devices were classified as fishing or not fishing immediately after deployment. A fraction of the devices were checked by video camera on November 13, and classified as fishing, not fishing, or missing. All remaining devices were recovered on December 10. Those not lost* were classified as intact, damaged, or missing. (* Devices were designated as lost when whole gangs or parts of gangs were not recoverable and missing when individual devices had broken off of an existing gang.)

Gang #	1	2	3	4	5	6	7	8	9	10	all	
TRAPS												
DEPLOYMENT												
# set	100	100	100	100	100	100	100	100	100	186	1086	
fishing	97	100	99	98	100	97	96	94	95	185	1062	(98%)
not fishing	3	0	1	2	0	3	4	6	5	0	24	
CHECK												
# checked	0	99	58	0	0	0	0	100	0	85	342	
fishing	-	94	53	-	-	-	-	87	-	74	308	(90%)
not fishing	-	1	4	-	-	-	-	3	-	5	13	
missing*	-	4	1	-	-	-	-	10	-	6	21	
# not checked	100	1	42	100	100	100	100	0	100	101	744	
RECOVERY												
# not lost*	100	51	0	100	0	100	76	100	100	186	813	
intact	93	27	-	74	-	78	33	31	71	113	520	(64%)
damaged	0	13	-	18	-	21	8	3	4	5	72	
missing*	7	11	-	8	-	1	35	66	25	68	221	
# lost*	0	49	100	0	100	0	24	0	0	0	273	
NETS												
DEPLOYMENT												
# set	100	100	100	100	100	100	100	100	100	32	932	
fishing	91	89	91	95	93	88	98	96	89	31	861	(92%)
not fishing	9	11	9	5	7	12	2	4	11	1	71	
CHECK												
# checked	0	99	57	0	0	0	0	99	0	0	255	
fishing	-	50	24	-	-	-	-	43	-	-	117	(46%)
not fishing	-	48	33	-	-	-	-	56	-	-	137	
missing*	-	1	0	-	-	-	-	0	-	-	1	
# not checked	100	1	43	100	100	100	100	1	100	32	677	
RECOVERY												
# not lost*	100	51	0	100	0	100	76	100	100	32	659	
intact	97	44	-	100	-	90	69	91	98	32	621	(94%)
damaged	3	7	-	0	-	10	7	2	2	0	31	
missing*	0	0	-	0	-	0	0	7	0	0	7	
# lost*	0	49	100	0	100	0	24	0	0	0	273	

Figures

Figure 1. Julian's Reef in southwestern Lake Michigan (adapted from Holm et al. 1987). Depths are in feet.

Figure 2. Substrate and bathymetric maps produced from side-scan sonar records of the south-eastern portion of Julian's Reef. a) Substrate map. b) Substrate map overlain with bathymetry. c) Locations of gangs of egg-collection devices (numbered straight line segments, numbers correspond to gang numbers in Table 1) and paths of separate video reconnaisance transects (un-labelled line segments).

Figure 3. Bedrock pavement on the reef crest showing jointing and extensive pitting. Some pits have coalesced and all are infilled with sand. A single cobble-sized rock is perched on the bed-rock in the upper left background.

Figure 4. Bedrock ridges substrate. The ridge is about 10 cm high on flat pavement. The pave-ment at the base of the ridge is covered with a thin layer of sand.

Figure 5. Bedrock ridges substrate. The ridge is about 15 cm high. Loose, rubble-sized slabs of bedrock are present in the foregroung.

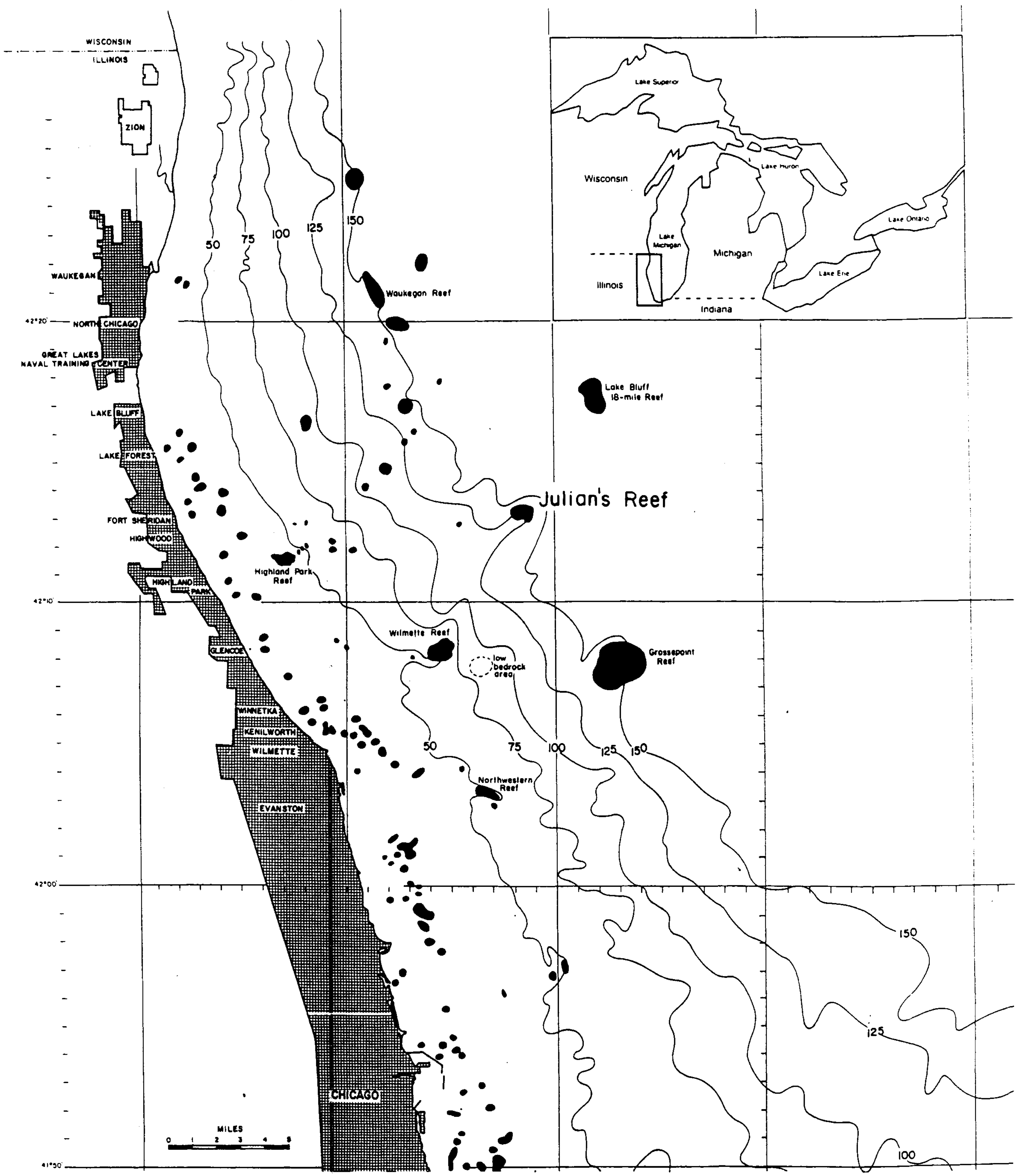
Figure 6. Bedrock ridges substrate. The ridge is about 1 m high. The face of the ridge is com-posed of loose, rubble-sized blocks of bed-rock, and the pavement at the base of the ridge is free of loose rock

Figure 7. Bedrock and rubble substrate. Angular, rubble-sized slabs of broken bedrock are piled along a pavement step. Interstitial depth is about 15 cm.

Figure 8. Bedrock and rubble substrate. Slightly rounded rubble-sized rock is piled to a depth of about 30 cm in an accretion area. Interstitial depth exceeds 20 cm.

Figure 9. Bedrock and sand (or bedrock and silt) substrate. The bedrock is more deeply jointed than at the reef crest, giving it a lumpy appearance, and the surface of the bedrock is completely covered in patches with a layer of sans (or silt).

Figure 10. Rubble and sand substrate.



WISCONSIN
ILLINOIS
ZION
WAUKEGAN
NORTH CHICAGO
GREAT LAKES
NAVAL TRAINING CENTER
LAKE BLUFF
LAKE FOREST
FORT SHERIDAN
HIGHWOOD
HIGHLAND PARK
GLENCOE
WINNETKA
KENILWORTH
WILMETTE
EVANSTON
CHICAGO
42°20'
42°10'
42°00'
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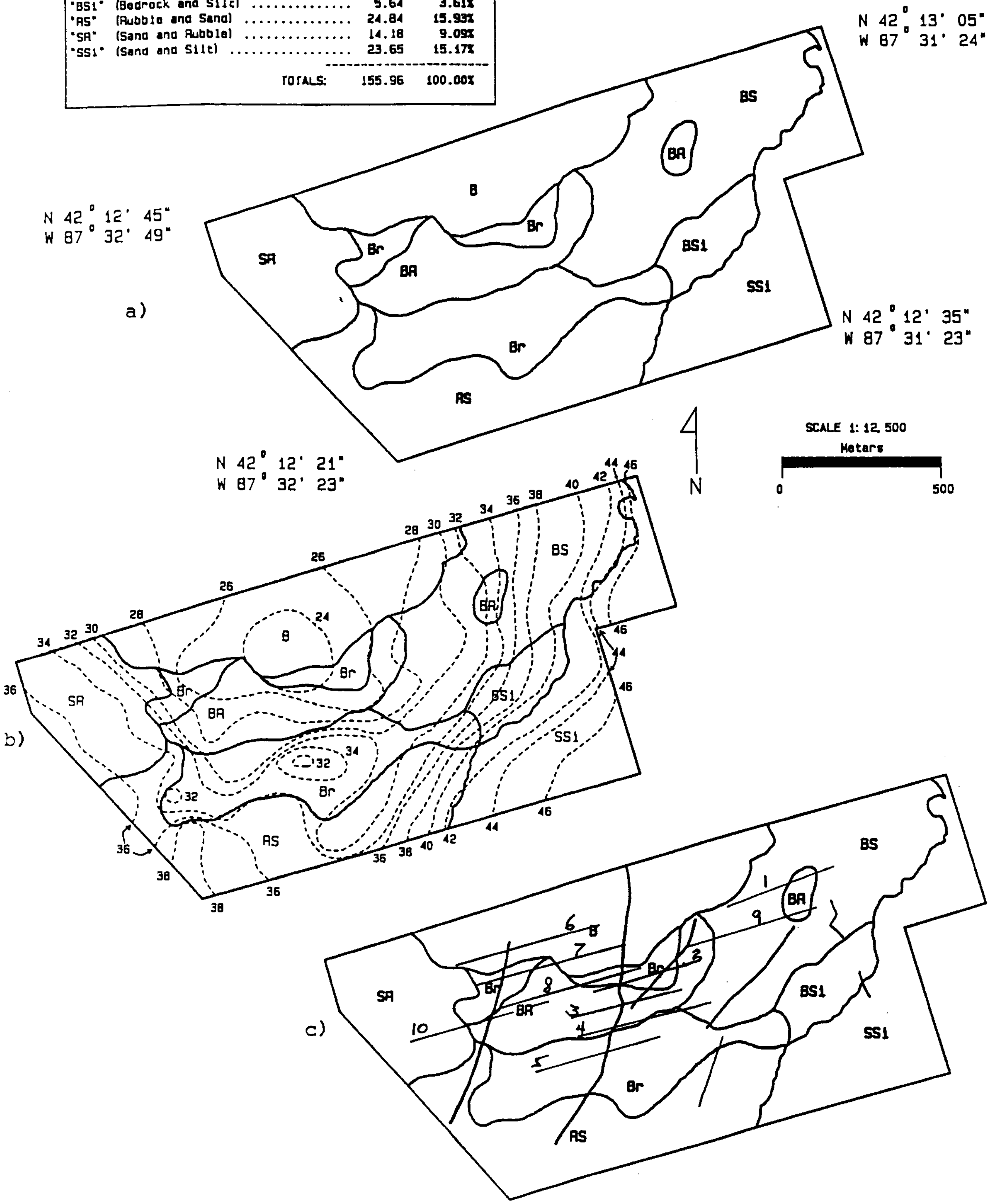
MILES
0 1 2 3 4 5
50
75
100
125
150
Waukegan Reef
Lake Bluff
18-mile Reef
Julian's Reef
Highland Park
Reef
Wilmette Reef
low
bedrock
area
Grossepoint
Reef
Northwestern
Reef
Lake Superior
Lake Huron
Wisconsin
Lake Ontario
Lake Michigan
Michigan
Lake Erie
Illinois
Indiana

Figure 1

LEGEND

SUBSTRATE DESCRIPTION		AREA IN HECTARES	%
"B"	(Bedrock)	23.46	15.04%
"Br"	(Bedrock ridges)	22.37	14.35%
"BR"	(Bedrock and Rubble)	13.34	8.55%
"BS"	(Bedrock and Sand)	28.48	18.26%
"BSi"	(Bedrock and Silt)	5.64	3.61%
"RS"	(Rubble and Sand)	24.84	15.93%
"SR"	(Sand and Rubble)	14.18	9.09%
"SSi"	(Sand and Silt)	23.65	15.17%
	TOTALS:	155.96	100.00%



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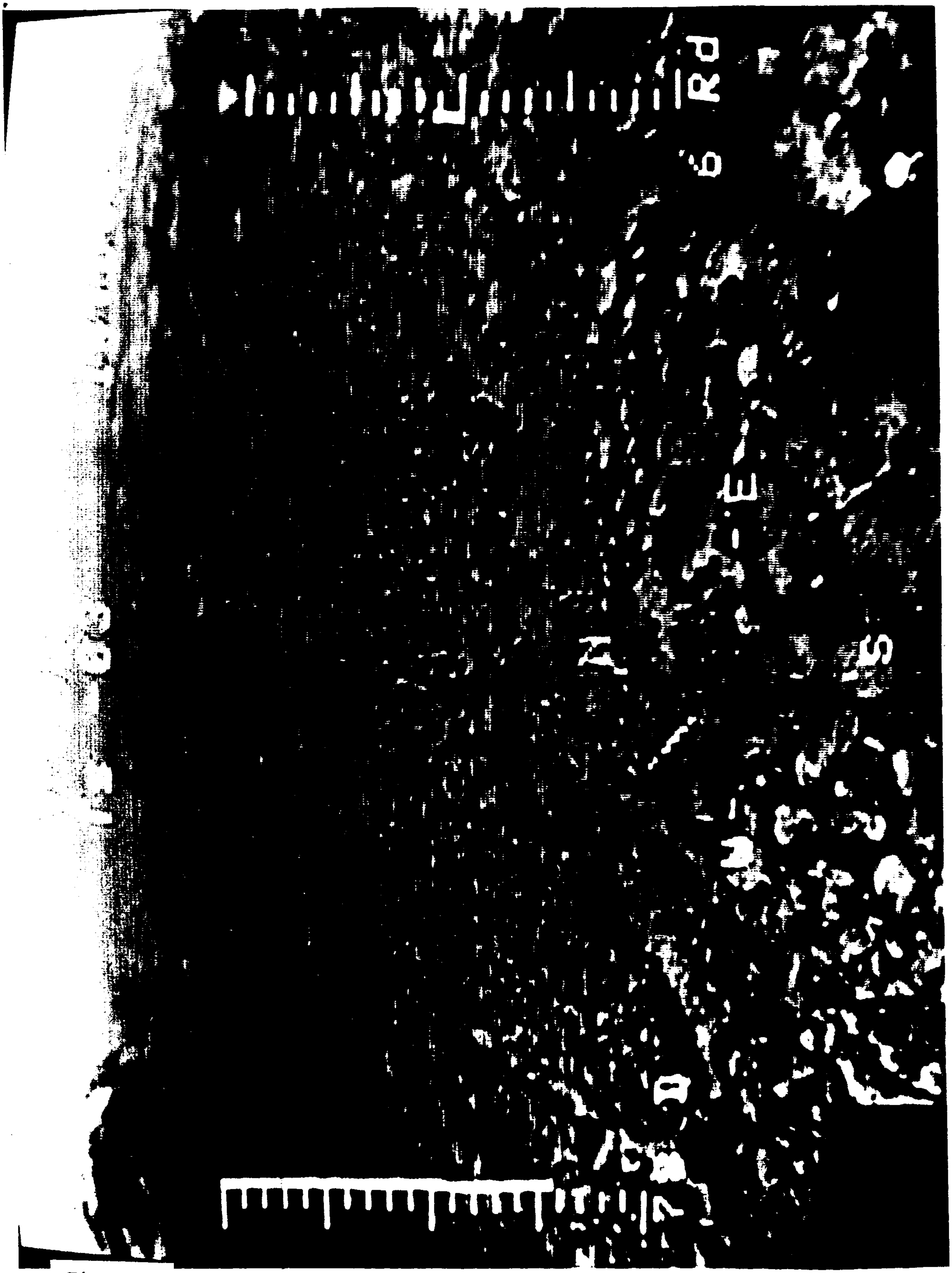

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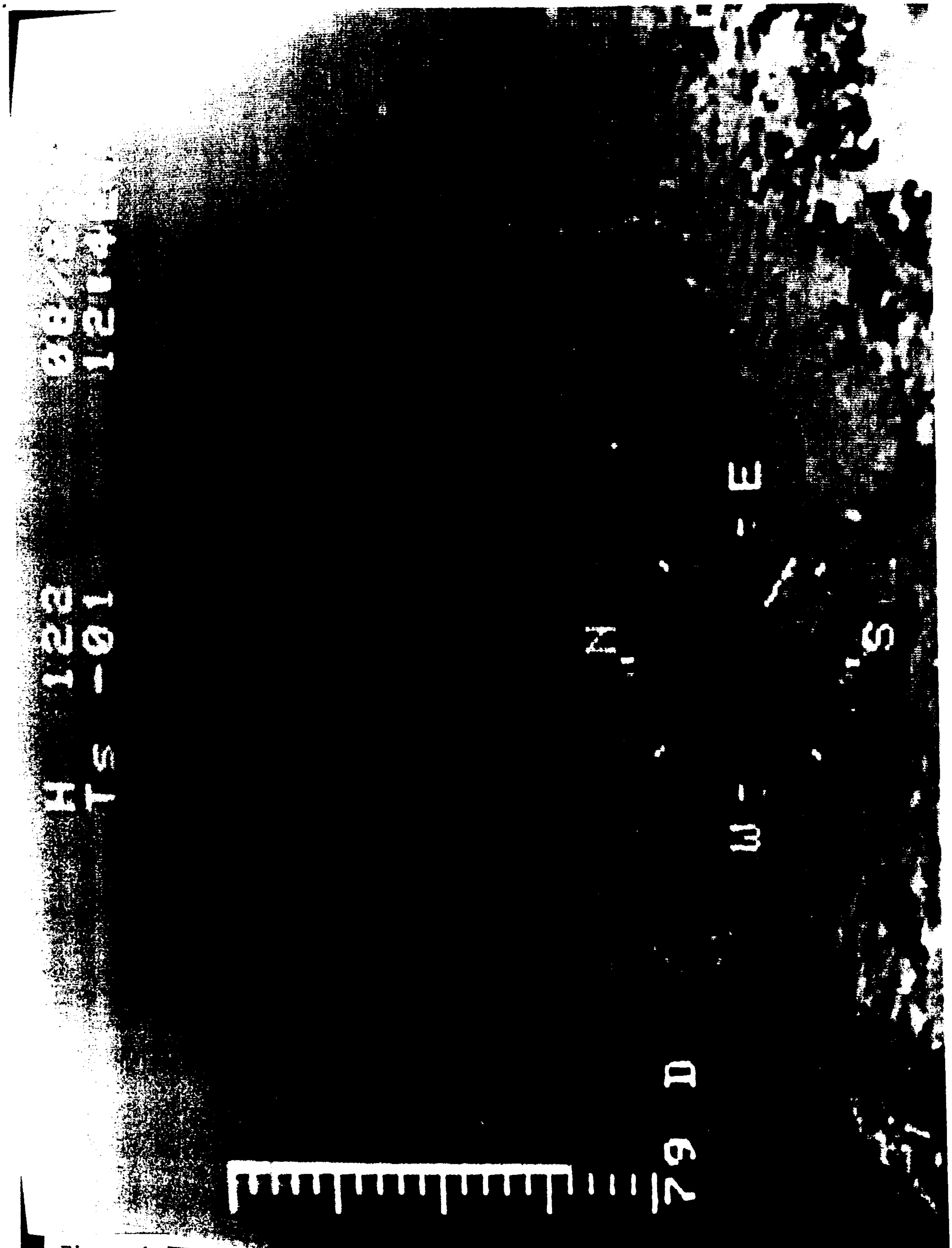

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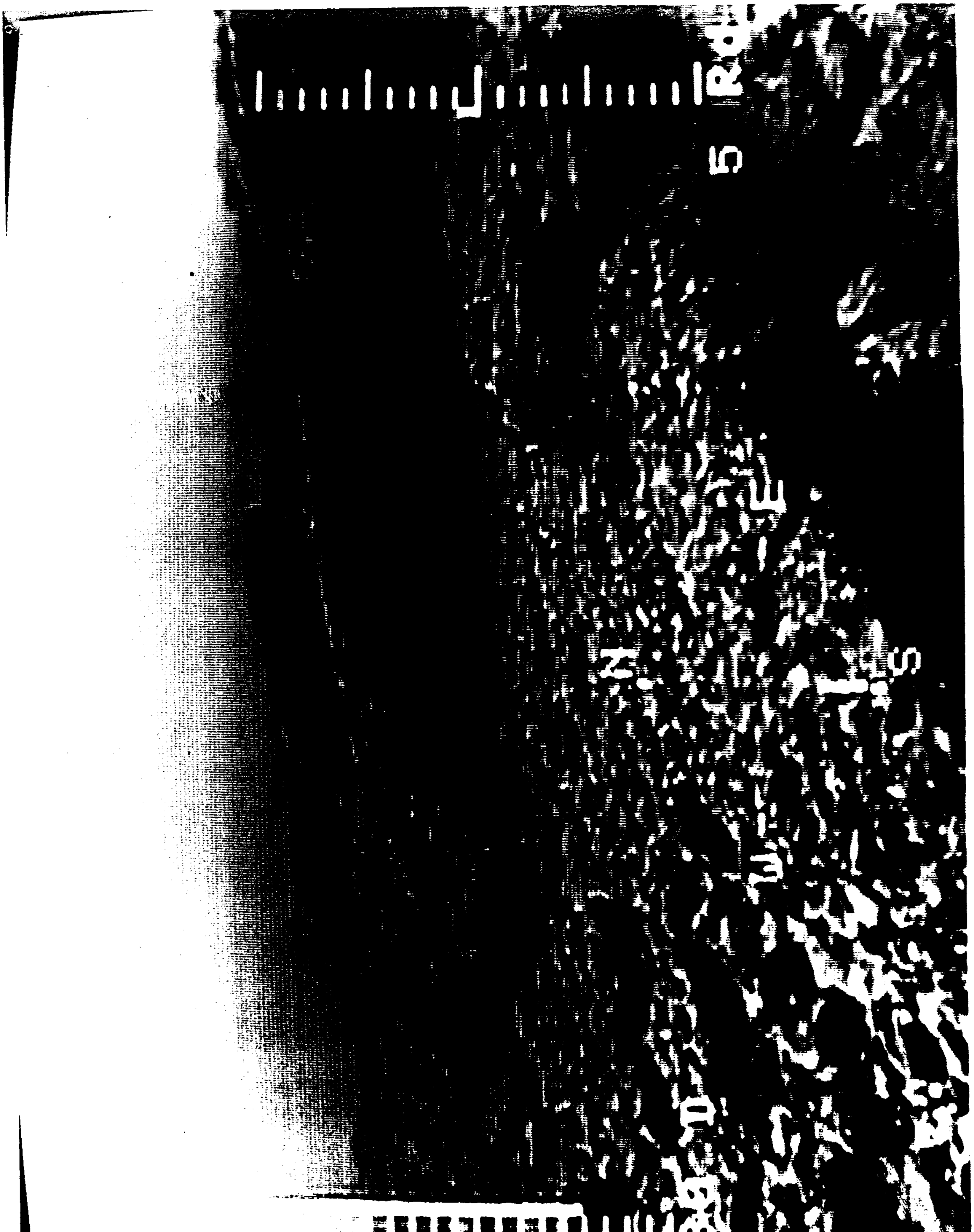

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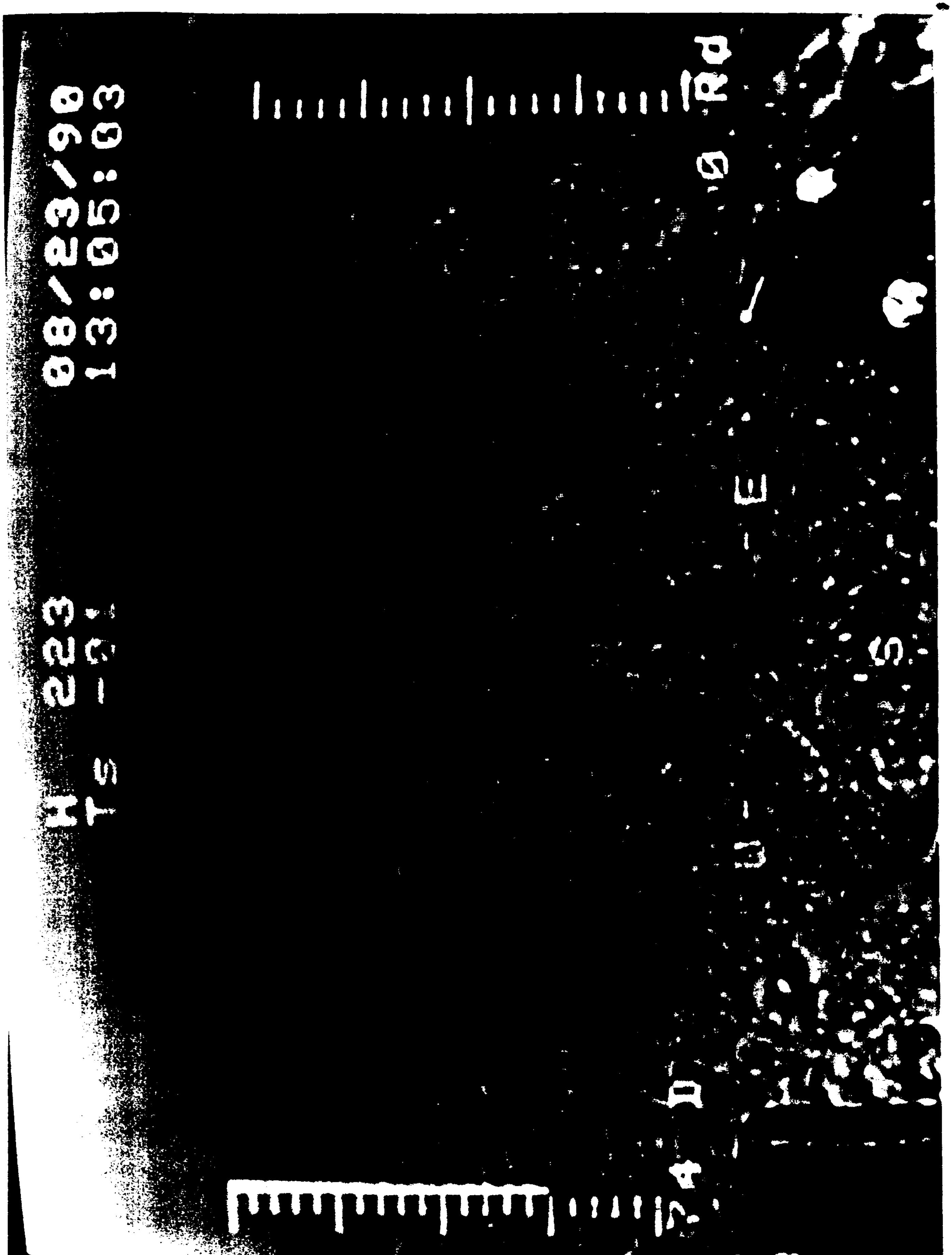

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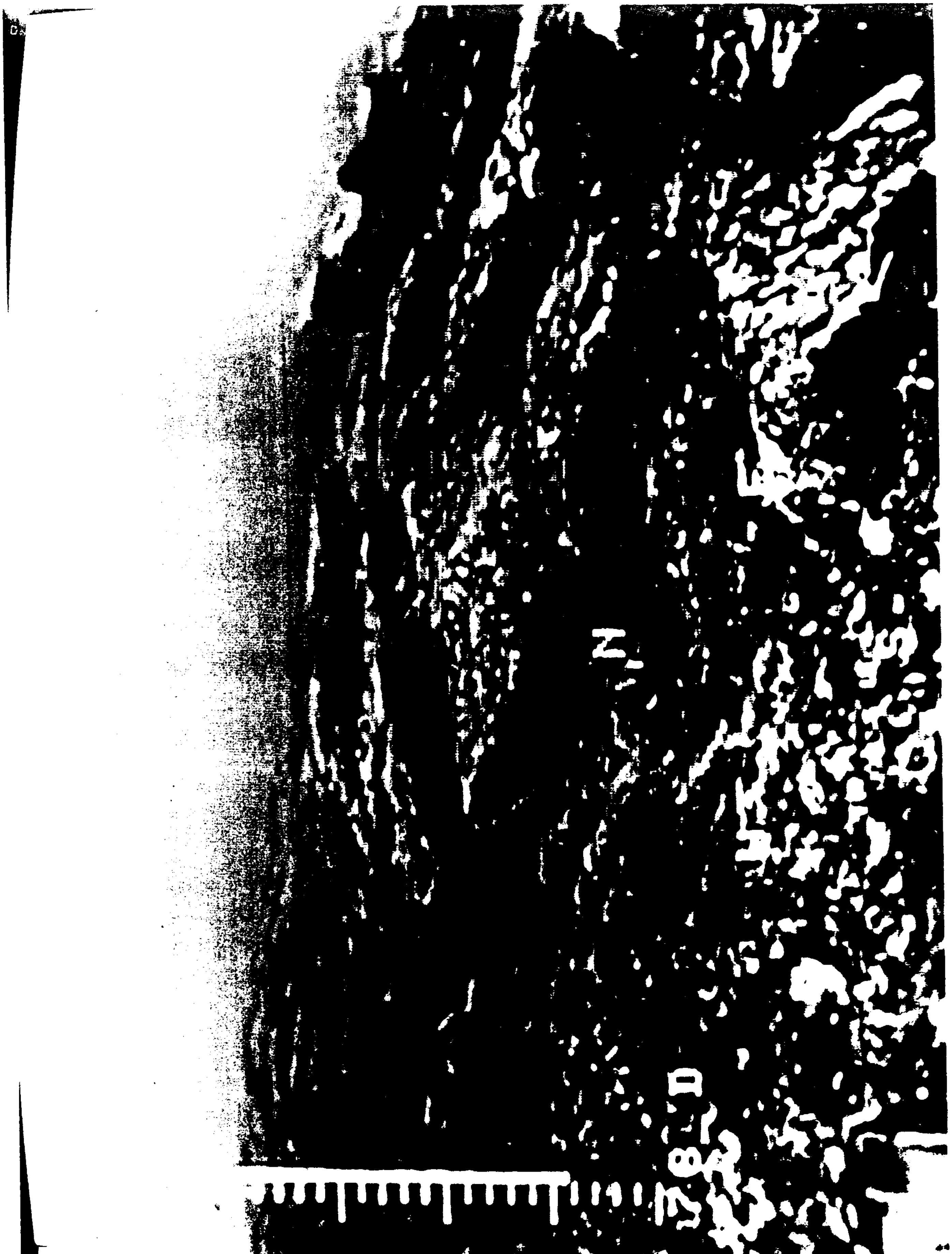

Figure 7

Figure 8

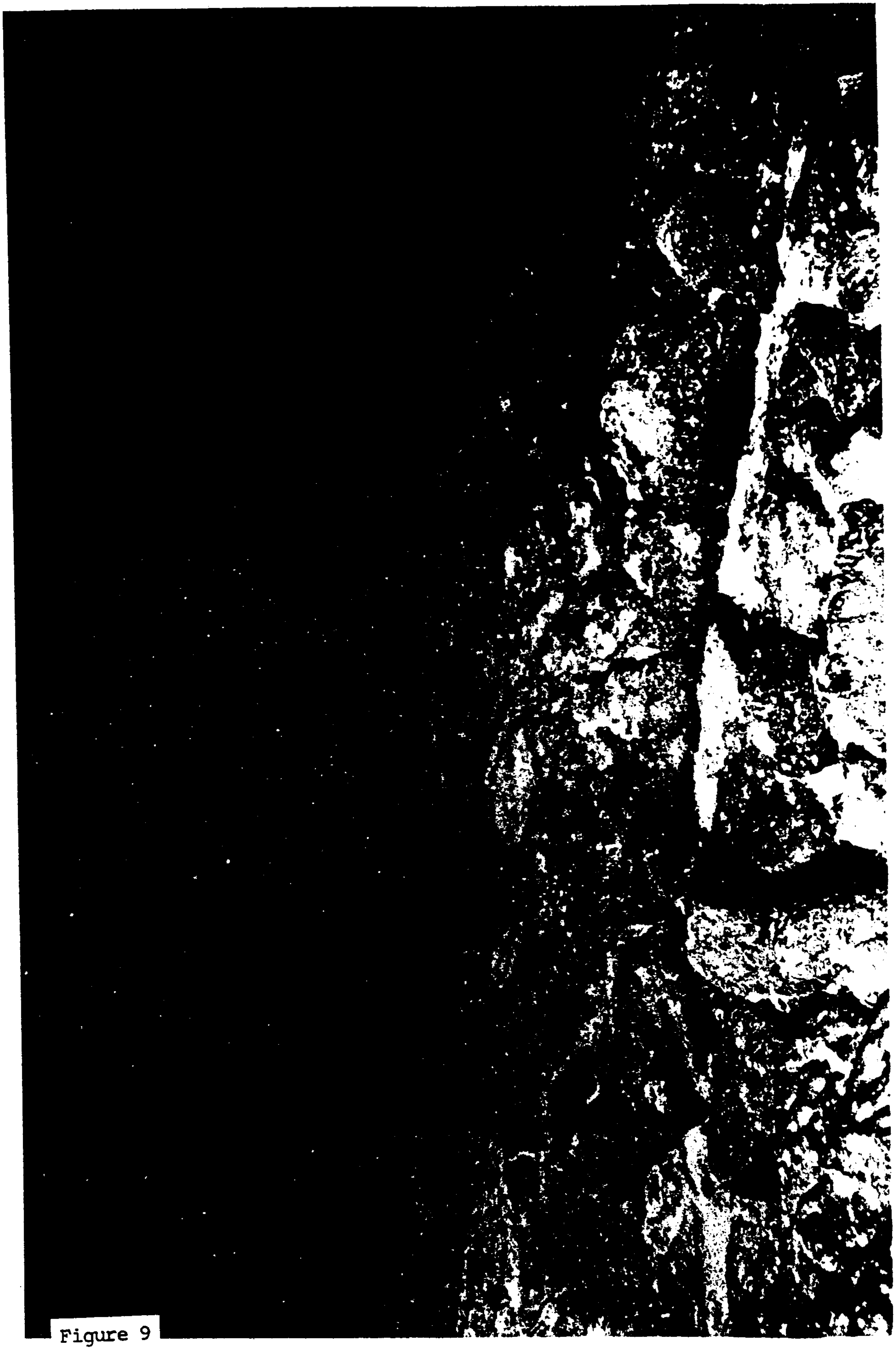

Figure 9

Figure 10